

**METHODS FOR GRAPHICALLY REPRESENTING INTERACTIONS AMONG  
ENTITIES**

**Related U.S. Application**

5        This is a continuation of pending U.S. Application  
Serial No. 09/726,884 filed November 30, 2000, which is  
incorporated by reference herein. This application also  
claims priority from U.S. Provisional Application Serial  
No. 60/234,503 filed on September 22, 2000, which is  
10    incorporated by reference herein.

**Background Of The Invention**

One of the most valuable assets of a company, if not  
the most critical one, is its intellectual capital which,  
15    among other things, includes human assets. A company can  
maximize its intellectual capital only if it understands  
its key elements and how these elements interact with each  
other to add value to the company. Understanding the  
nature of the interactions between these elements can  
20    reveal significant information about and for the company.  
More and more companies today acknowledge the importance  
and relevance of such interactions, and allocate

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significant resources to analyze and utilize these interactions. Successful companies manage to extend these interactions well beyond the company boundaries by analyzing interactions with customers, partners, suppliers and alliances as well. Essentially, such interactions, whether explicit or implicit, define specialized human networks with complex organizational dynamics.

While the importance of human networks is well understood for effective organizational management, existing methodologies by which such networks can be analyzed are not well-defined. Existing methodologies generally rely on statistical sampling and/or informal opinion polling techniques which are neither complete nor reliable. Typically, they are ad hoc and do not include the entire target population in analyses. Also, existing methodologies focus on qualitative rather than quantitative analyses of organizational interactions.

Furthermore, at present, the only way to display interactions among entities that is known to the inventor is the brute-force documentation of interactions in either a spreadsheet or a directed graph structure. "Entity" as used herein includes individuals as well as groups, such as a department within a corporation. Directed graphs function by explicitly linking entities and while typically

easier to understand and glean information from than  
spreadsheets, are not satisfactory as the number of  
entities and the number of interactions increase.

What is desired, therefore, is a graphical approach  
5 that overcomes the disadvantages of the existing graphical  
approaches and provides a compact, multi-level interaction  
context from which desired information can be gleaned  
expeditiously.

### 10 Summary Of The Invention

The purposes of the invention described above and  
other objects are achieved by methods for graphically  
representing interactions among entities within an  
organization. These methods, in their basic form, include  
15 providing graphical objects corresponding to the entities,  
varying graphical properties of the graphical objects to  
correspond to preselected attributes of the entities, and  
displaying on a display screen the graphical objects and  
interactions between the entities represented by the  
20 graphical objects.

The specific graphical methods described and claimed  
include interactions between units within an organization,  
interactions between members within a unit of an

organization, interactions between a member and other members within an organization, interactions between hypothetical units within an organization, and interactions between members of units within an organization. As used  
5 herein, "organization" denotes any grouping of individuals or units of individuals, including communities and companies.

#### Brief Description Of The Drawings

10 **FIG. 1** shows a flow diagram illustrating the preferred embodiment of the interactive visual analysis methodology of the present invention.

**FIG. 2** shows an organization view under view generation of the interactive visual analysis methodology  
15 of **FIG. 1**.

**FIG. 3** shows another organization view under view generation of the interactive visual analysis methodology of **FIG. 1**.

**FIG. 4** shows a group view under view generation of the  
20 interactive visual analysis methodology of **FIG. 1**.

**FIG. 5** shows an individual view under view generation of the interactive visual analysis methodology of **FIG. 1**.

FIG. 6 shows the individual view of FIG. 5 at a higher depth value.

FIG. 7 shows a cluster view under view generation of the interactive visual analysis methodology of FIG. 1.

5        FIG. 8 shows a people map under view generation of the interactive visual analysis methodology of FIG. 1.

#### **Detailed Description Of The Preferred Embodiment**

Figure 1 is a flow diagram illustrating the preferred embodiment of the interactive visual analysis methodology of the present invention. This methodology structure includes data collection, generally indicated by reference numeral 100, data analysis and processing, generally indicated by reference numeral 110, view generation, generally indicated by reference numeral 120, and interaction analysis, generally indicated by reference numeral 130.

Data collection 100 includes accumulating interaction data by employing appropriate data collection mechanisms. For example, sources of interaction data include, but are not limited to: (1) Network surveys which poll an entire target population, including people within or outside an organization; (2) E-mail traffic with or without content-based classification; (3) Phone traffic; and (4) Access to

shared resources, including but not limited to, files, documents, programs and systems.

Database analysis and processing 110 includes processing the collected interaction data with auxiliary data, such as employee, client, product and/or content data. This step may also include applying statistical, heuristic or clustering techniques -- using appropriate measures, strategies and benchmarks -- to the processed data, and deriving additional data to enhance and enrich the processed data. There are two important concepts here: connectivity and diversity measures.

Connectivity is a measure for assessing how well entities are connected to their environment. "Entity", as used herein, includes individuals as well as groups, such as a department within an organization. Generally, the connectivity measure is a recursive measure that uses an appropriate decay factor for accounting the effects of indirect connections (or interactions) up to a certain level of depth. Connectivity may be measured in different ways. The following general formulation may be used as a basis for connectivity analysis:

$$C(E, L) = \sum_{1 \leq k \leq N} [w(k) + C(k, L-1)/f_d] \quad C(E, 0) = 0$$

In this formula,  $C(E, L)$  denotes connectivity of entity  $E$  at depth  $L$  where  $E$  has  $N$  direct connections (interactions),  $w(k)$  is the weight of direct connections from  $k$ , and  $f_d$  is the decay factor. While several  
5 alternatives exist for decaying the effects of indirect connections, typically either a distance-based measure or a degree-based measure is used as a decay factor.

Diversity is a measure for assessing how diverse entities are in their interactions with or connections to  
10 their environment. As with the connectivity measure, the diversity measure is also a recursive measure that uses an appropriate decay factor for accounting the effects of indirect interactions (connections) up to a certain level of depth. Depending on analysis needs, diversity may be  
15 measured along dimensions, such as age, gender and business types. Diversity may be measured in different ways. The following general formulation may be used as a basis for diversity analysis:

$$D(E, L) = \sum_{1 \leq k \leq N} [v(k, p) + D(k, L-1)/f_d]$$

$$D(E, 0) = 0$$

In this formula,  $D(E, L)$  denotes diversity of entity  $E$  at depth  $L$  where  $E$  has  $N$  direct connections (interactions), and  $v(k, p) = 0$  if the property of  $k$  along the diversity

dimension of interest is already within  $p$ , where  $p$  is a set of properties encountered so far, including the property of  $E$ . Otherwise,  $v(k,p) = 1$ . Again,  $f_a$  is the decay factor for adjusting the effect of indirect connections. Using

5 connectivity and diversity measures in heuristic rules, the data analysis and processing step may also classify entities in a given network into categories outlining the criticality of entities in the network.

View generation 120 involves generating views

10 corresponding to different depictions of the interaction data after the analysis and processing of step 110. Since these views are related and provide different aspects of the same data, appropriate interactive mechanisms are also provided to move from one view to another. In the

15 embodiment of FIG. 1, there are six different types of views provided. Each and every one of these views is for exemplary purposes only, and it should be apparent to one of ordinary skill in the art that modifications may be made to these exemplary views without departing from the scope

20 or spirit of the present invention.

First, an organization view arranges selected organizational units hierarchically, where units are represented in terms of graphical objects encoding certain data attributes using objects' graphical properties. An



exemplary organization view is shown in Figure 2, where color and location of each square box encode the relative position of the corresponding unit within an organizational hierarchy. While boxes on the innermost rectangle (layer) correspond to higher-level (parent) units, boxes on the outer layers correspond to lower-level (sub) units. Color of boxes simply encode the 'part of' relationships between units at different layers. While the size of a box represents a scalar value such as the degree of internal and external interactions of members of the corresponding unit, the gray area within each box shows the portion of internal interactions.

In an organization view as shown in FIG. 2, any box can be selected to see how the corresponding unit interacts with other units, which is conveyed in terms of directed links having varying thickness. The direction and thickness of a link encode the direction and strength of interactions between two groups connected by the link. Besides one-to-many interactions between a selected unit and the rest, many-to-many interactions among selected units can also be displayed within an organization view as shown in Figure 3.

A second type of view provided in the example of FIG. 1 is a group view. Group view displays individual members

of selected units along with their relevant attributes within a context, as illustrated in Figure 4. In a group view, individuals are enclosed within a large bounding box having the same color as the selected unit in the organization view. In order to provide a context for the selected unit, all units that are at the same level as the parent of the selected unit are shown on a line at the top of the view. All units having the same parent as the selected unit are also shown on a line at the bottom of the view. The leftmost boxes on the top and bottom lines correspond to the parent and the selected units, respectively. As in an organization view, entities in a group view are represented in terms of graphical objects, such as boxes that are arranged hierarchically. While the size of a box represents a scalar value, such as the degree of internal and external interactions of the corresponding individual, the color may be used to encode additional attributes, such as gender, location or criticality classification.

A third type of view provided in the example of FIG. 1 is an individual view. Individual view represents an interaction record (print) of a selected individual. By definition, an individual's interaction print consists of directed interaction of that individual with others.

"Directed interaction", as used herein, implies that the interaction is initiated by an individual who is the source and has a target as another individual who is the sink.

Generally, an interaction print is a recursive structure

5 representing direct and indirect interactions of an individual. In an individual view, each square represents an individual. While the largest square corresponds to the individual whose interaction print is on display, the squares to the right and to the left having the same  
10 vertical positioning (i.e., on the same horizontal line as the largest square) represent individuals who are sources and sinks, respectively.

Then, for each individual who is either a source or a sink, a separate interaction print with one less depth  
15 level is created by listing the individuals who interact with that individual as sink above and as source below the individual's box having the same horizontal positioning (i.e., on the same vertical line). Repeating the process N times essentially creates an interaction print having a  
20 depth value which equals to N. In Figures 5 and 6, two interaction prints, one with depth=2 and the other with depth=4, are shown, respectively.

The use of boxes to represent entities has no underlying significance, other than simplicity. It should

be apparent to one skilled in the art that the use of any other object to represent an entity is within the scope of this invention. Likewise, while the relative position and size of a box with respect to other boxes are used to

5 encode important relationships among corresponding entities, the absolute position and size of boxes have no underlying significance. Although it is not utilized in the current example, the ordering of boxes on any arbitrary side of a box to represent an ordinal attribute of entities

10 is within the scope of this invention. In individual views, color of each box may encode a particular nominal attribute of an entity. For example, color as used in Figures 5 and 6 may represent departmental affiliation of entities within an organization.

15 A fourth type of view provided in the example of FIG. 1 is a cluster view. Cluster view defines hypothetical groups within an organization based on existing networks. These hypothetical groups or clusters may be formed either by applying appropriate clustering techniques to the

20 interaction data or moving people from one group to another in the current organization manually. In a cluster view, the composition of clusters are shown in terms of pie charts as illustrated in Figure 7. It should be apparent to one of ordinary skill in the art that the use of pie

charts is for exemplary purposes only and is not limited thereto. In a way similar to the display of interactions among units in an organization view, interactions between clusters are conveyed by directed links having varying thickness. While the size (radius) of pie charts encode the size of corresponding clusters, colors are used to show the current affiliation of people that make up each cluster.

A fifth type of view provided in the example of FIG. 1 is a people map. A people map provides a hierarchical graph that organizes people into organizational or functional units. In a people map, as shown in Figure 8, each person who is selected to be in the map is represented by a rectangle whose size is proportional to the connectivity of the person and whose color is determined by the diversity of the person. Since all people in a unit fill the rectangular space allocated for the unit, the connectivity of the unit is also proportional to the size of the space it fills. The dominant color in the space allocated to the unit indicates the diversity of unit's interaction or connections. For example, the AMS/PBI block in the lower left corner of the people map in Figure 8 has lower diversity than those of other comparable units, which have a higher level of diversity.

1 A sixth type of view provided in the example of FIG. 1  
is a topical view. Topical views may include all other  
views that have been described so far, where views may  
focus on different interaction topics ranging from general  
5 to specific. That is, each of the view types discussed so  
far displays a particular topical view involving a topic or  
an area of interaction among entities. While some of the  
general topics may include execution, expertise, ideas,  
teamwork and advice, specific topics may include domain  
10 specific issues, such as hedge fund networks in finance,  
magnetic resonance imaging networks in medicine or skiing  
networks in recreational activities. Classifying e-mail or  
shared resources based on content gives way to numerous  
topical interactions.

15 In a preferred embodiment of the views described  
above, when a graphical object, such as a box or a circle,  
is pointed to or otherwise indicated or selected by an  
input device, such as mouse, keyboard, voice recognition  
system, etc., a brief summary of interactions of the  
20 corresponding entity is displayed dynamically within a pop-  
up information window or the like. In addition, selecting  
a graphical object by an input device causes a detailed  
view or additional information about the entity associated  
with the object to be provided. It should be apparent to

one of ordinary skill in the art that when a graphical object is pointed to or otherwise indicated or selected, the information of the corresponding entity may be presented in many different ways without departing from the scope or spirit of the present invention.

Interaction analysis 130 as shown in FIG. 1 involves generation of one or more of the views in an appropriate order as dictated by analysis tasks at hand. Some of the analysis tasks that may be supported by the process include: interaction management at organization, group and individual levels; integration of organizations, groups and individuals over time; client relationship analysis and management; critical resource identification; cluster analysis; and diversity analysis. In the embodiment of the invention described herein, not all interaction analysis tasks require the use of all views. While some of the analysis tasks can only be performed by information analysts who are experts in organization and people management, others can be performed as part of a discovery process by people who are members of the target audience.

An additional step that may be included to the methodology of the present invention in FIG. 1 is report and advice generation 140. Report and advice generation 140 involves presenting analysis results at an appropriate

level of abstraction to the target audience. While domain knowledge is required to tailor reports or advice, this process lends itself in automating basic reports and advice.

5       The present invention has various useful applications. First, it may be used to understand roles and traits of entities, such as people or groups, within an organization where entities interact with each other dynamically and possess attributes. Second, it may be used to integrate  
10 other entities into an existing organization in an efficient and effective manner, and help them develop and grow with the changing organization over time. Third, it may be used for client relationship management and analysis. Fourth, it may be used to restructure an  
15 existing organization to improve its productivity and profitability. And fifth, it may be used for identification of critical human resources. While these are only a few specific applications of the present invention, the underlying methodology, in general, may be  
20 used as an effective vehicle for organizational knowledge and/or intellectual capital management.

The hardware/software needed to implement the present invention generally includes the following components: (1) a networked computing infrastructure, (2) server side



computing resources, and (3) client side computing resources.

Since the invention involves collecting interaction data from such diverse sources as surveys, e-mail logs, phone records and shared resource access logs, a networked computing infrastructure capable of supporting data collection by polling individuals or monitoring their interactions within a distributed environment is desired. Given that such computing infrastructures are commonly available in many organizations, most of the software needed to collect data can be developed by using existing languages, utilities and/or tools in a platform-dependent manner with proper access to relevant databases.

The server side computing resources include the following preferred components: (1) database(s) capable of storing all interaction, auxiliary and derived data; (2) a web server capable of authenticating information access requests, retrieving appropriate subsets of data from the database and sending the resulting data in an appropriate format to the client side requesting the information; and (3) a proprietary code base implementing parts of the data extraction, view generation, interaction analysis and report/advice generation steps on the server side.

The client side computing resources include the following preferred components: (1) a set of generic technologies, such as cookies and Java-enabled browsers; and (2) a proprietary code base implementing parts of the view generation, interaction analysis and report/advice generation steps on the client side.

Those skilled in the art will recognize that the methods of the present invention have other applications, and that the present invention is not limited to the representative examples disclosed herein. Moreover, the scope of the present invention covers conventionally known variations and modifications to the methods described herein, as would be known by those skilled in the art.